PULSE PROPAGATION AND WAVE REFLECTION IN ARTERIES: NEW INSIGHTS USING ADVANCED MODELING METHODS

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Objective: Non-invasive diagnostic devices for arterial stiffness often synthesize information related to the propagation and reflection of pressure pulses throughout the arterial system. These phenomena are, however, complex and still not fully understood. **Methods:** We return to the basics by studying the propagation and reflection of a short, isolated pressure pulse in a straight and tapered aorta (see Figure 1) mimicking the foot of the physiological pressure wave. Theoretical pulse wave velocity (PWV_{th}) in the straight model was 4.88 m/s. It increased from 4.38 to 5.35 m/s (average 4.88 m/s) in the tapered model. Additional simulations included a local stiffening (≈ a non-obstructing repaired aortic coarctation). Full 3D numerical fluid-structure interaction simulations with a short time step (1ms) were used. Reflected waves at the distal end were suppressed, thus isolating the effects of reflection due to aortic tapering and the presence of the rigid segment. **Results**: In both control models, PWV_{ff} was higher than PWV_{th} (5.50 and 5.60 m/s resp.). Interestingly, a so-called "precursor wave" appeared in the simulations (see e.g. at t≈0.025 s at the outlet), traveling back and forth within the arterial wall at a speed approximately 3 times higher than PWV_{th} (16.5 m/s; Figure 1). Tapering amplifies the forward wave (Figure 1C). In the tapered model, the backward wave shows the same pattern induced by the precursor waves, but with an offset indicating continuous wave reflections. The stiff segment induced backward waves proximal to the rigid zone; distally, the forward traveling wave was reduced by approximately 9%. **Conclusions:** PWV_{ff} does not match the theoretical PWV and aortic tapering complicates the unequivocal interpretation of wave reflections. The co-appearance of a fast-traveling wave in the arterial wall warrants further (in vivo) investigations, but may open new perspectives for more direct characterization of the mechanical properties of arterial tissue.